UNIVERSITY OF ZAGREB
FACULTY OF MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE
DEPARTMENT OF ENERGY, POWER AND ENVIRONMENTAL ENGINEERING

"Renewable energy on islands: electricity storage and integration challenges"

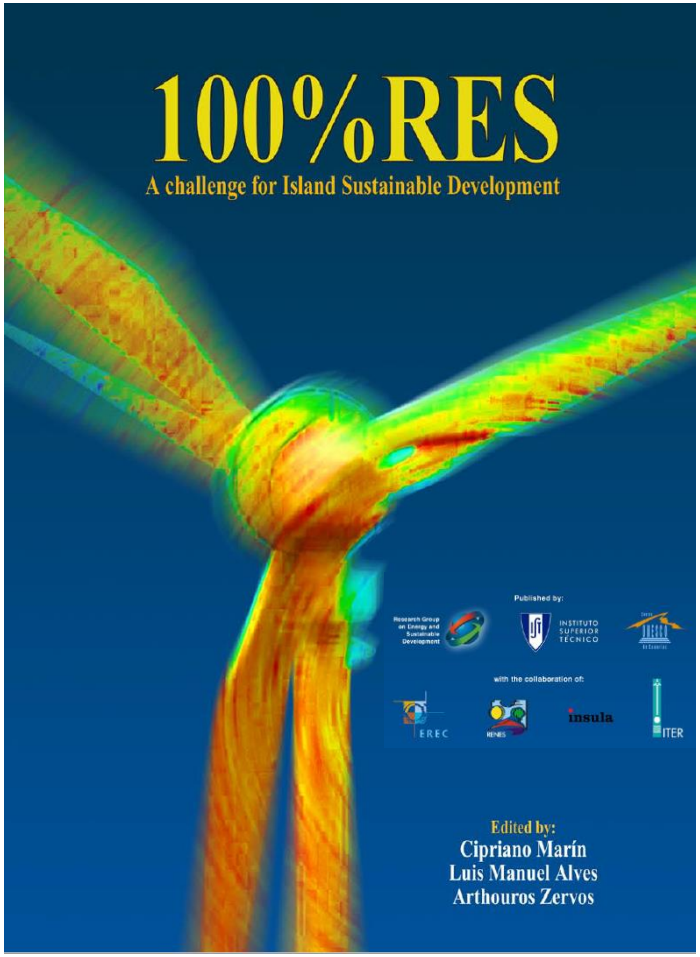
assoc. prof. Goran Krajačić

WEBINAR

Mon, Feb 10, 2020 1:00 PM - 2:00 PM CET

CLEAN ENERGY FOR EU ISLANDS

- Islands and renewables
- RENEWISLANDS
- Energy modelling – Smart energy systems
- Islands Indexation
- User cases INSULAE and other projects
- Deployment of technology on islands
- Conclusions


100%RES
A challenge for Island Sustainable Development
Published by:
with the collaboration of:
EREC
RENES
insula
ITER
Edited by:
Cipriano Marín
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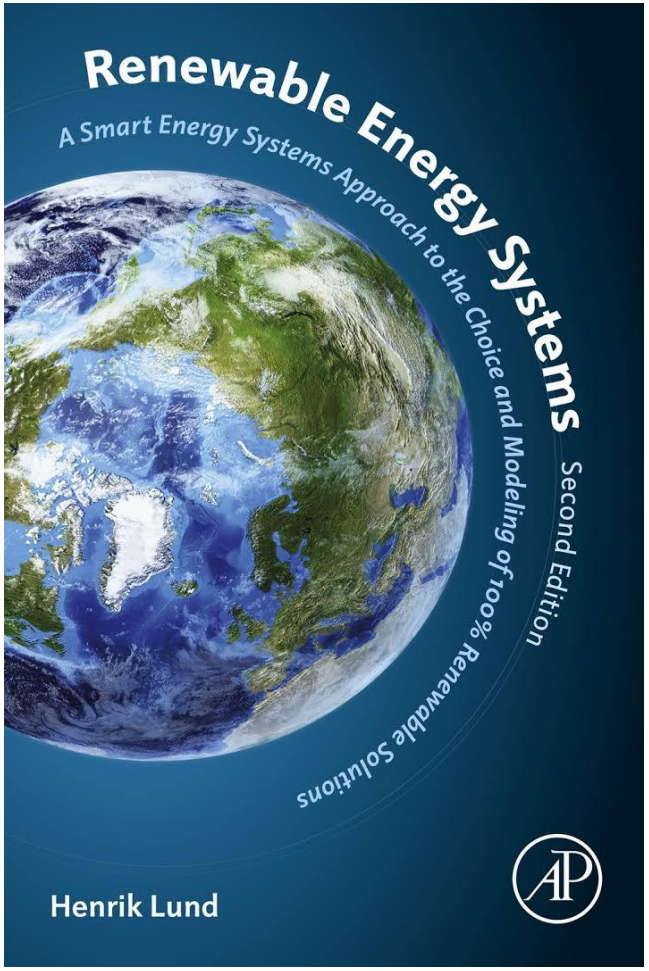
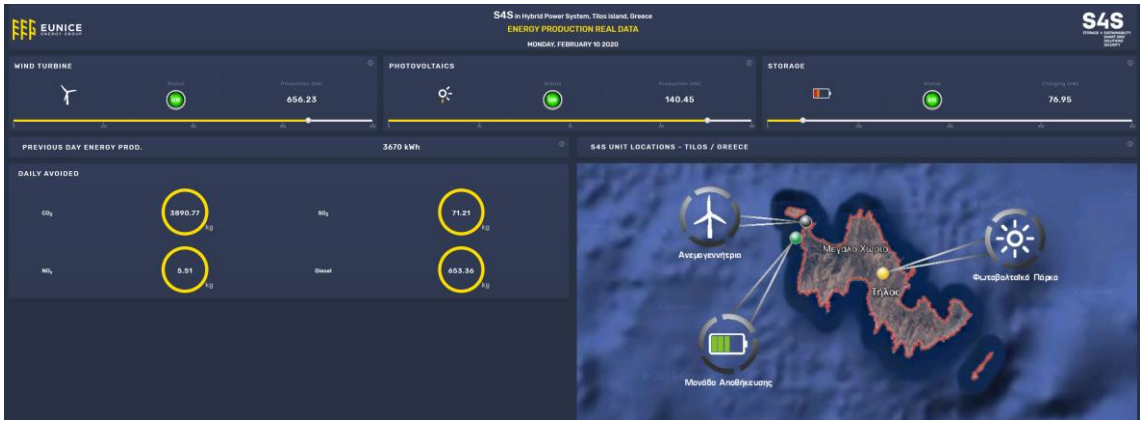
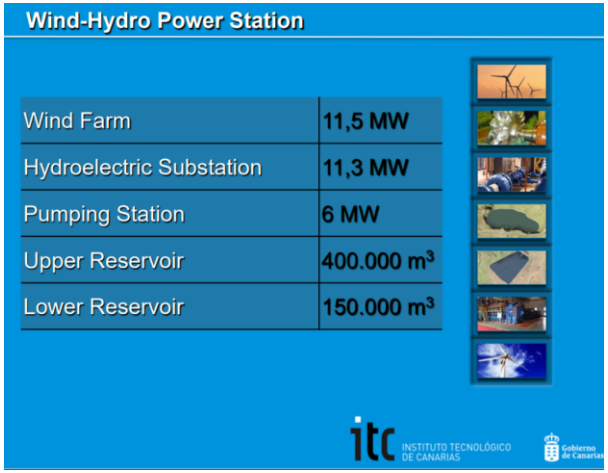
Arthouros Zervos


Renewable Energy Systems
A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions
Second Edition
Henrik Lund

- El Hierro Island – Wind + pumped hydro + desalination (0 → 80% of RES electricity)
  - Gonzalo Piernavieja Izquierdo, Instituto Tecnológico de Canarias Islands as References of Circular Economy Models: Potentials and Challenges, 11th SDEWES conference (http://www.lisbon2016.sdewes.org/lectures.php)
- Tilos Island (wind + solar PV + battery)
  - http://s4s.eunice.gr/





- Samsø (grid connected, wind, PV, biomass district heating, LNG ferry, EV)
- Bornholm (grid connected, wind, PV, CHP, biomass district heating, smart grids, EV)
- Orkney: (grid connected, wind, small wind, solar, smart grid, hydrogen Nines project http://www.ninessmartgrid.co.uk/)

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RenewIslands/ADEG METHODOLOGY

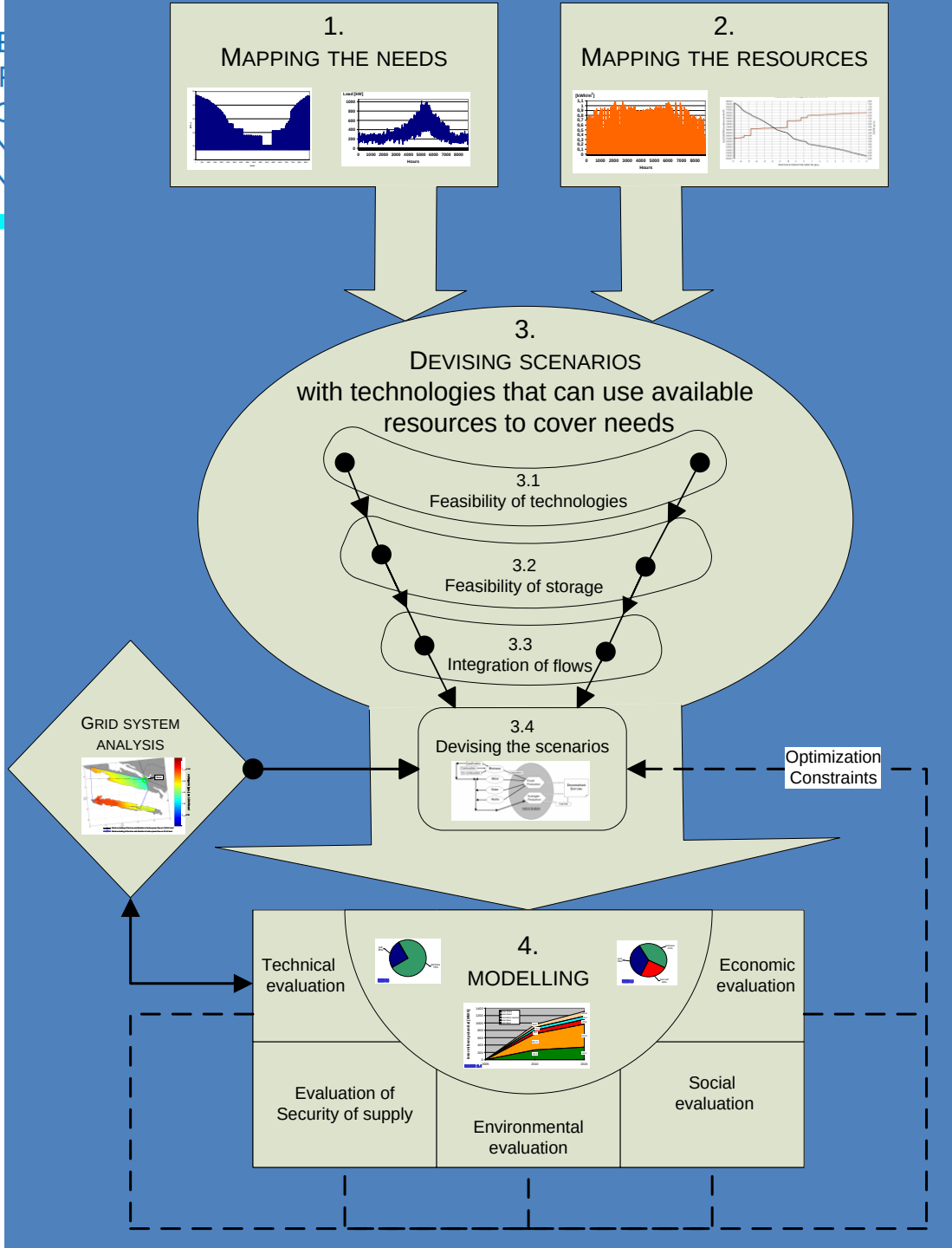
1. Mapping the needs
2. Mapping the resources
3. Devising scenaria with technologies that can use available resources to cover needs
4. Modelling the scenaria

ELSEVIER

Renewable and Sustainable Energy Reviews
Volume 12, Issue 4, May 2008, Pages 1032-1062

RenewIslands methodology for sustainable energy and resource planning for islands

Neven Duić [a], Goran Krajačić [a], Maria da Graça Carvalho [b, 1]



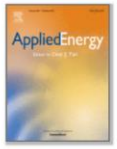
Smart energy systems

"We have to move away from a sole focus on areas like the electricity sector and look at the energy demands of the heating, cooling and transport sectors as well. We have to better connect the different sources and consumption areas – in a smart energy system."

Prof. Brian Vad Mathiesen, Aalborg University, Denmark

ELSEVIER

Applied Energy
Volume 251, 1 October 2019, 113290



On the transferability of smart energy systems on off-grid islands using cluster analysis – A case study for the Philippine archipelago

Henning Meschede [a] [1] ✉, Eugene A. Esparcia Jr. [b, 1], Peter Holzapfel [c], Paul Bertheau [d], Rosario C. Ang [e], Ariel C. Blanco [e], Joey D. Ocon [b] ✉

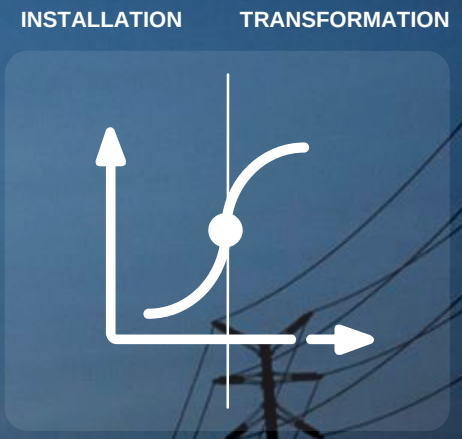
Show more

https://doi.org/10.1016/j.apenergy.2019.05.093

At an inflection point

ERICSSON
Ericsson Nikola Tesla d.d.

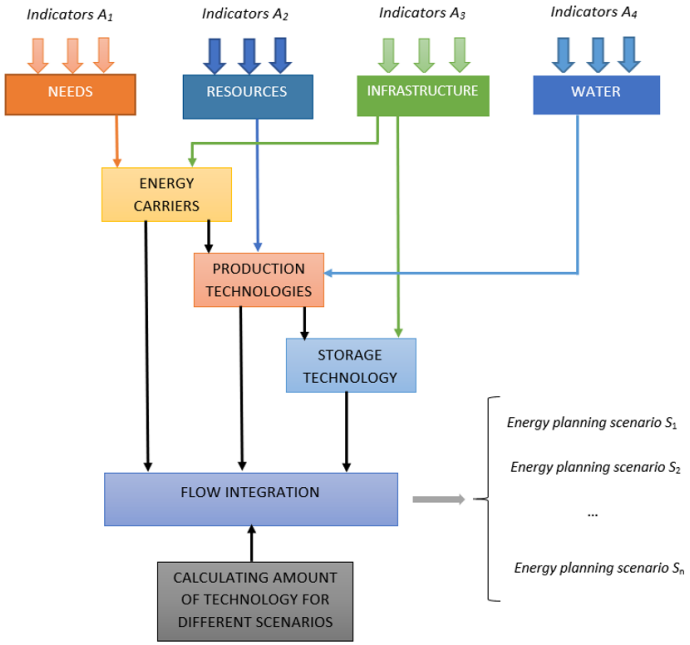
5G + IoT + Cloud



The 5th technological revolution

Indexation method

- Assessement of islands' needs, resources, infrastructure and water resources based on 40 indicators
- Compound RIS index calculated from normalized indicators



$$RIS(S_i) = k_1 \sum_{y=1}^{12} I_{1,y}(S_i) + k_2 \sum_{y=1}^{15} I_{2,y}(S_i) + k_3 \sum_{y=1}^{7} I_{3,y}(S_i) + k_4 \sum_{y=1}^{4} I_{4,y}(S_i)$$

where $\sum_{x=1}^{4} k_x = 1$

M.Mimica,G.Krajačić, Advanced RenewIslands method with quantitative mapping for islands' needs and resources, SDEWES Dubrovnik 2019.

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Maximizing the impact of innovative energy approaches in the EU islands

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Case study – 11 islands

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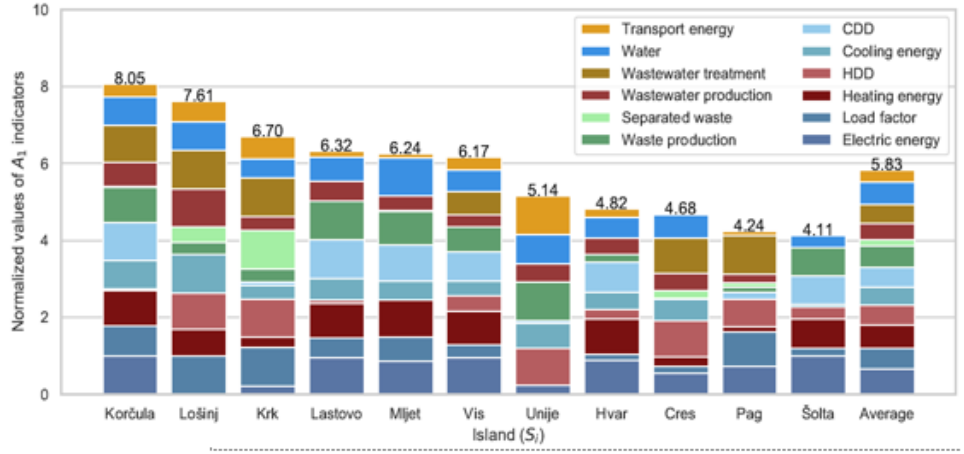
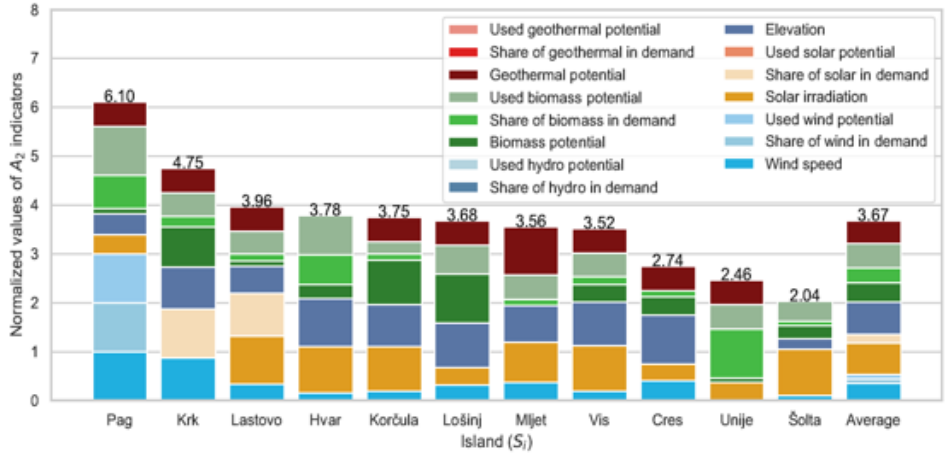
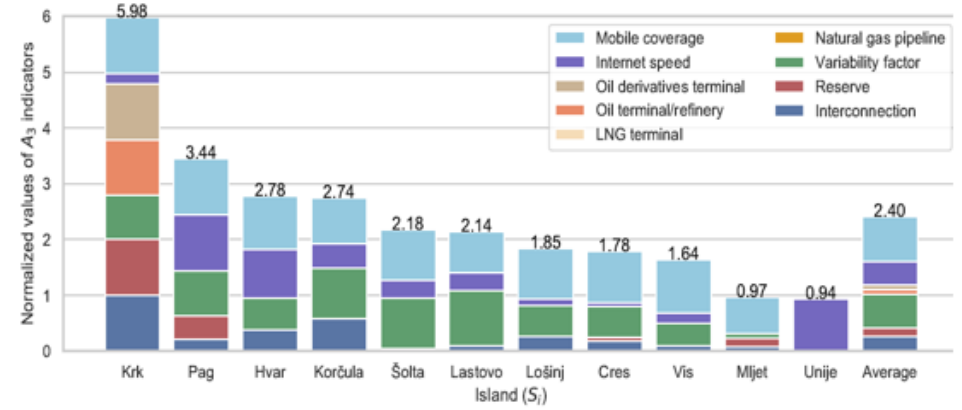
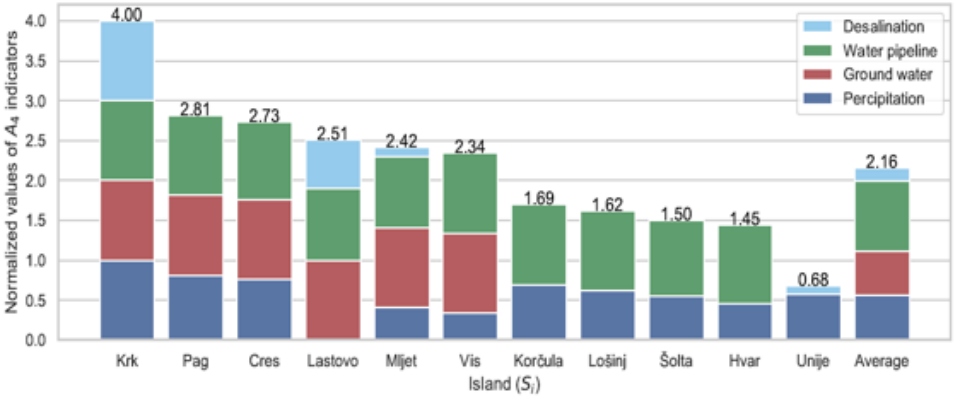




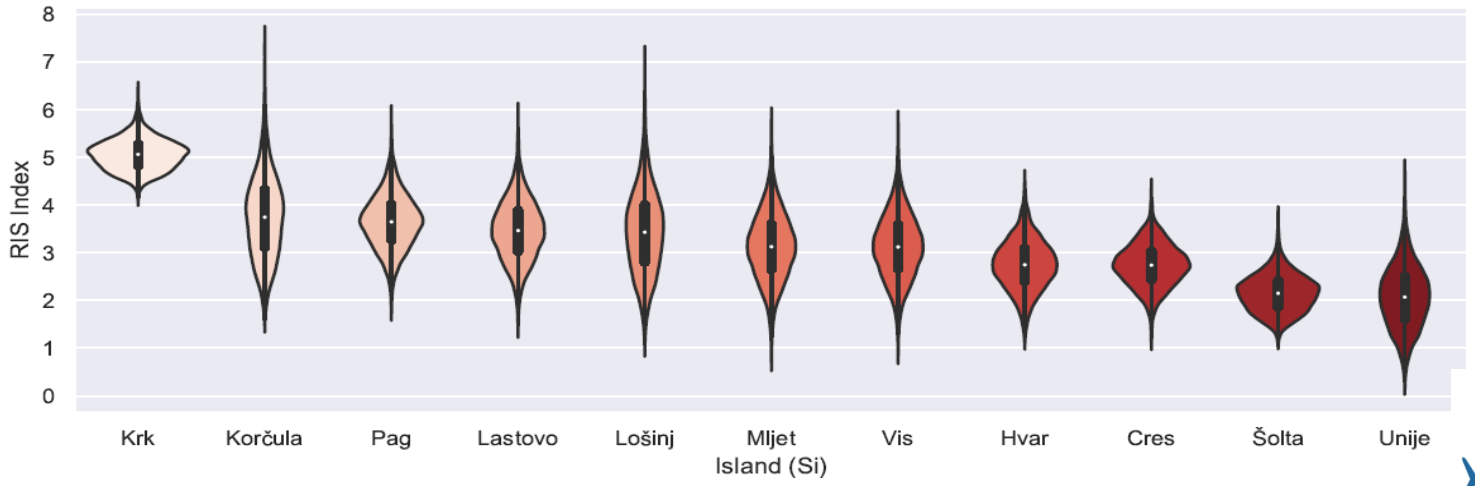




M.Mimica,G.Krajačić, Advanced RenewIslands method with quantitative mapping for islands' needs and resources, SDEWES Dubrovnik 2019.

- Ranking of islands
- Sensitivity of RIS index with Monte Carlo

	Otok (S_i)	RIS index	$\%\Delta S_i$
1	Krk	5.36	52.62
2	Pag	4.15	18.18
3	Korčula	4.06	15.67
4	Lastovo	3.73	6.38
5	Lošinj	3.69	5.10
6	Vis	3.42	-2.69
7	Mljet	3.29	-6.13
8	Hvar	3.21	-8.68
9	Cres	2.98	-15.00
10	Šolta	2.46	-29.99
11	Unije	2.31	-34.30
	Average	**3.51**	**0**



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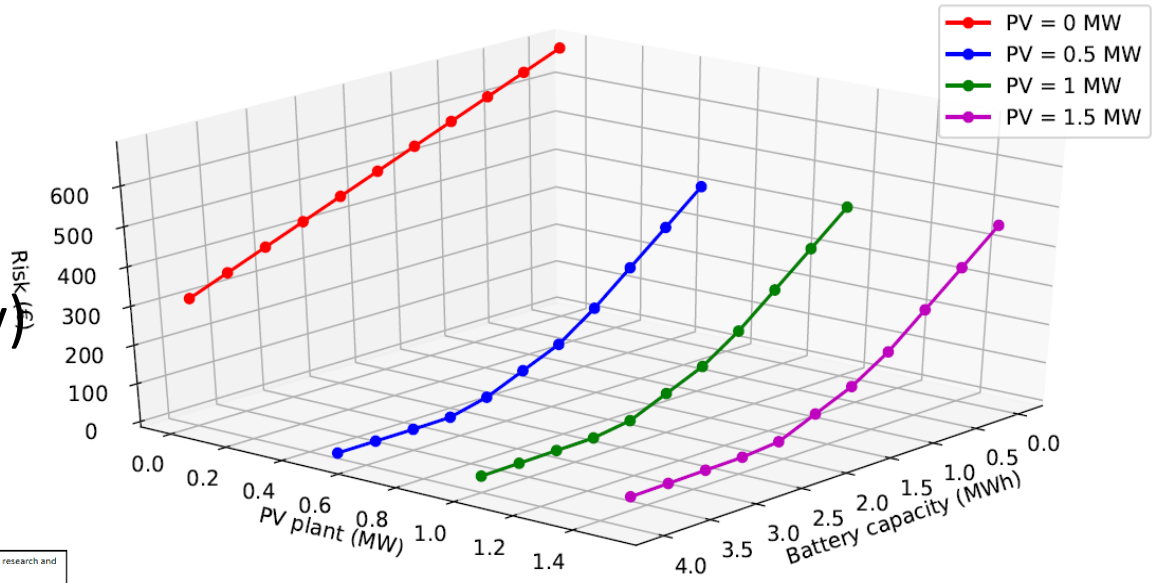
Risk assessment of energy scenarios on islands

- Probability of power system element failure based on Poisson distribution (probability matrix [**P**])
- Optimization model for calculation of demage as a result of power system element failure (damage matrix [**D**])
- Risk is [**R**] = [**P**] x [**D**]
- Zero-risk energy scenario for island Unije (0.5 MW PV and 3.2 MWh battery)



Marko.Mimica@fsb.hr

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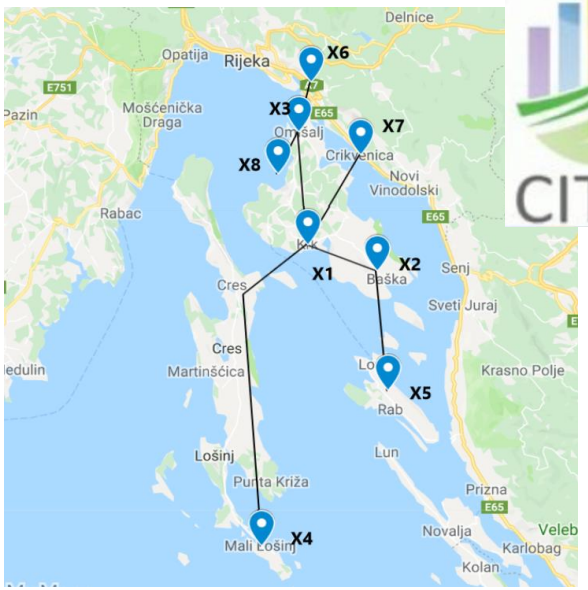
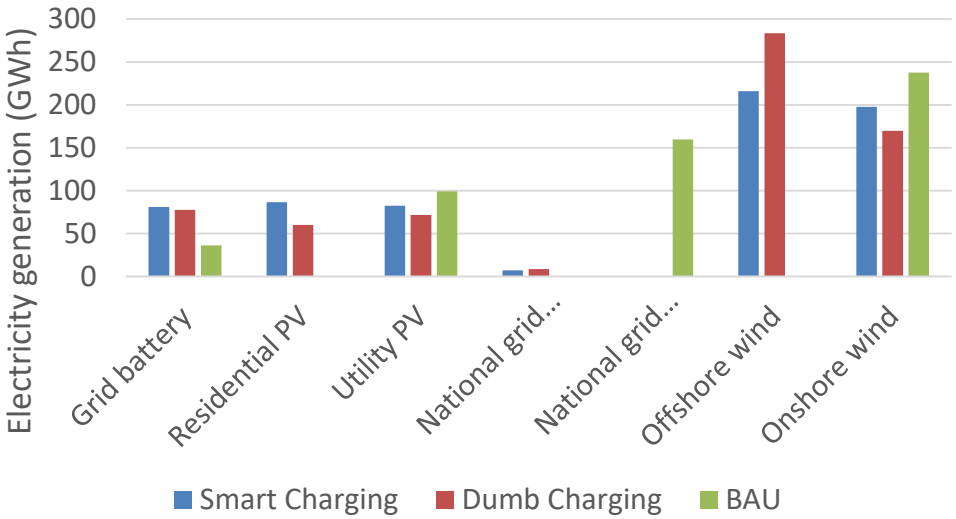
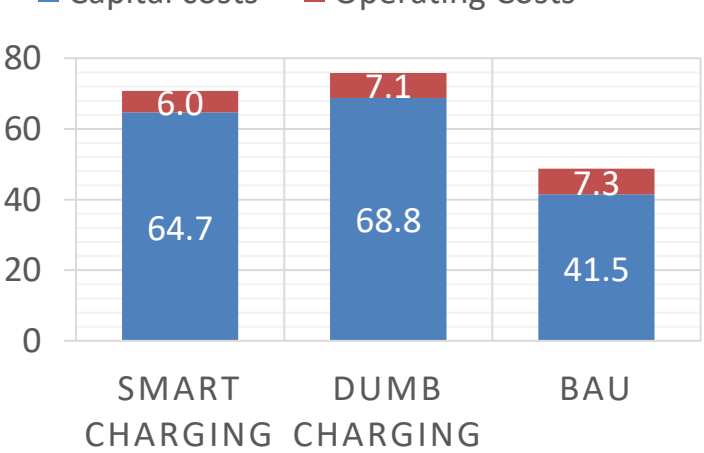
Energy modelling of Krk island

- Calliope model of Kvarner archipelago
- Three scenarios:
  - BAU
  - EV-Dumb charging
  - EV-Smart charging







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INSULAE http://insulae-h2020.eu/

- 7 use cases
- 3 lighthouse islands
- 4 follower islands
- Investment planning tools
- 27 project partners

USE CASES

- UC-1 Hybrid RES & storage
- UC-2 Smart control of water & energy
- UC-3 Energy communities through 5G & IoT
- UC-4 Transition to DC grids
- UC-5 Local bio-based economies
- UC-6 Electric transport
- UC-7 Stabilization of microgrids through storage

The results will validate an **Investment Planning Tool** that will be then demonstrated at 3 Follower Islands for the development of 4 associated Action Plans.

CONSORTIUM

The project team is carefully balanced along all the value chain counting with five public authorities, six energy and water utilities, four technology providers, two energy software developers, six RTOs, one environment NGO, one business models expert, one engineering company and one entity for social aspects and replication. The legal and regulatory framework of 57% of the total population living in EU islands will be directly considered within the project.

insulae

MAXIMIZING THE IMPACT OF INNOVATIVE ENERGY APROACHES IN THE EU ISLANDS

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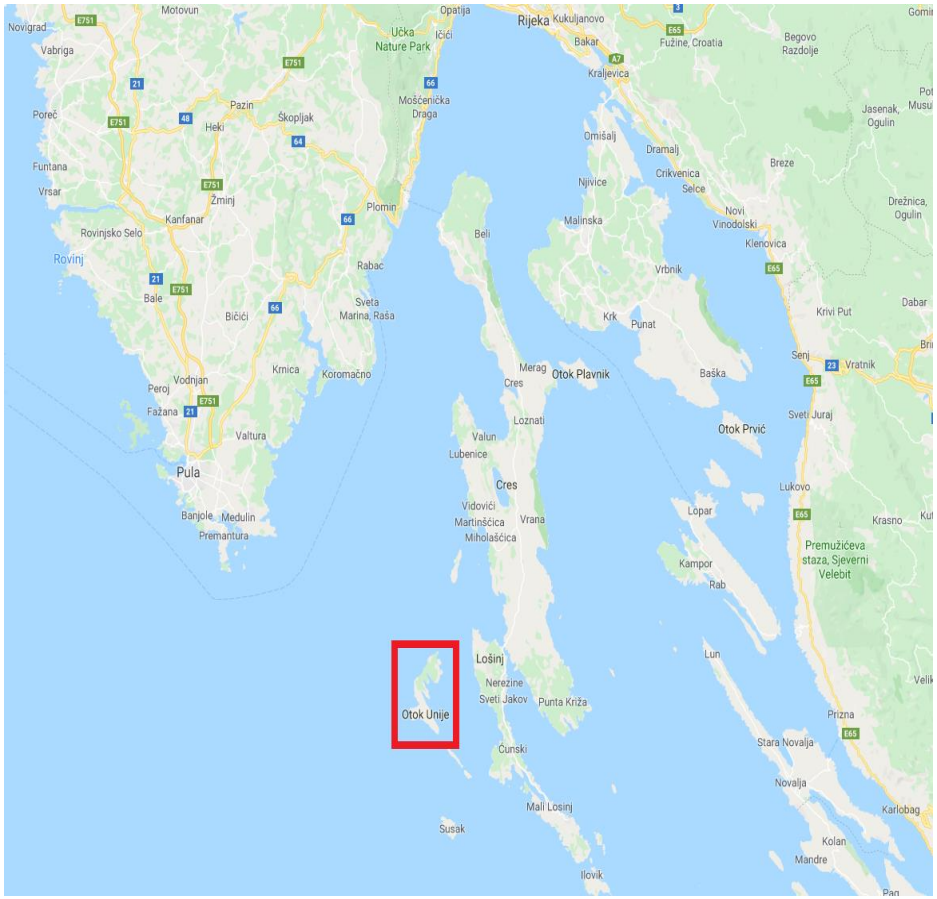
INSULAE project

- **Unije island**
- 88 residents
- Desalination plant 27 kW
- Strategy: „Island Unije – self-sustainable island”
- Partners from Croatia:
  - FSB
  - Ericsson Nikola Tesla
  - REA Kvarner
  - Water utility Cres i Lošinj
  - WWF Adria
  - HEP Croatian utility company (associate partner)



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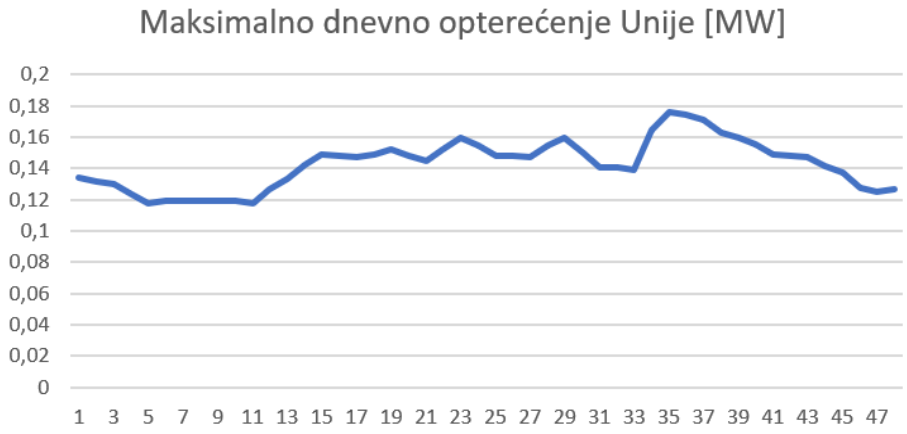
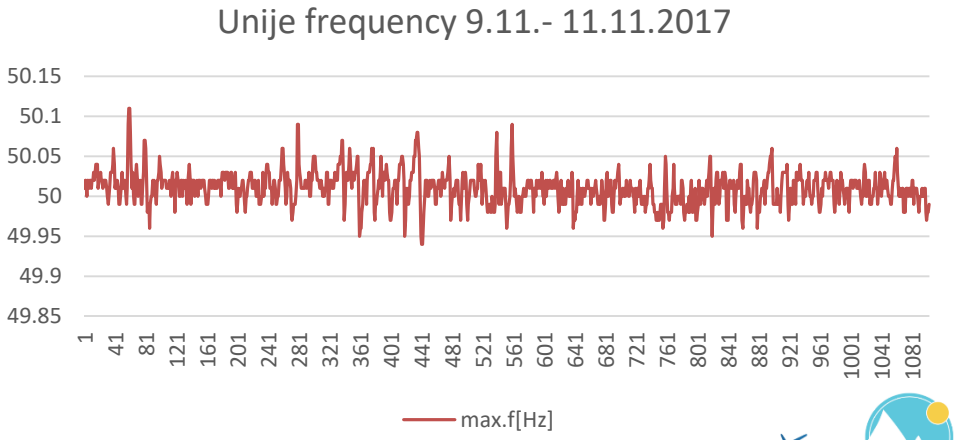
Joint management of solar power plant and battery system on Unije

- 1 MW solar + 0,4 MW/1,6 MWh battery
- Possibility to power the island for a minimum of four hours in case of power interruption from the external grid
- EnergyBox control unit

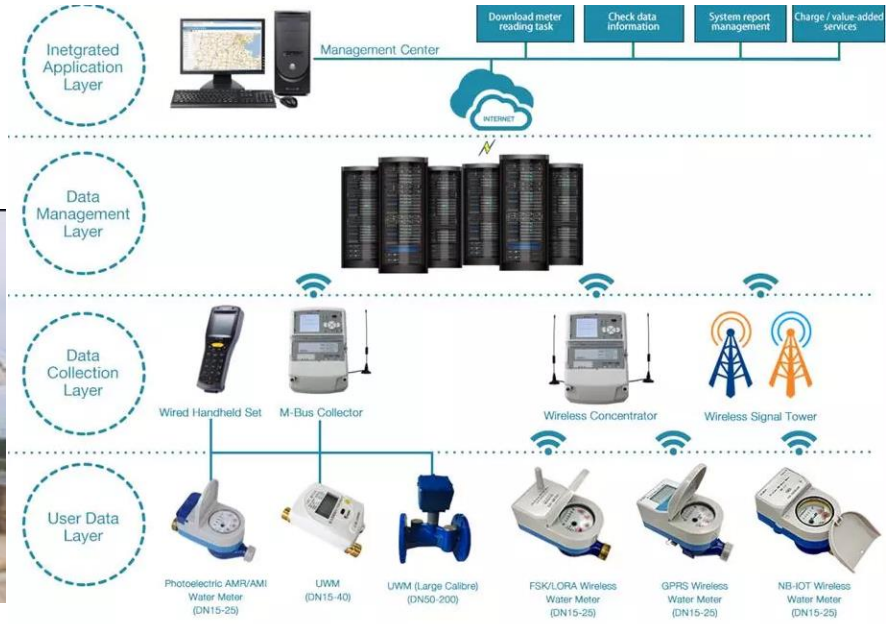




Measurement data substation Aerodrom, HEP Elektroprimorje 2017.

Smart integration and control of water and energy systems

- Water scarcity represents one of the main challenges for islands
- Desalination plant with 7 kW PV
- Integration of smart equipment
- Integration of 5G network



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Empowerment of island's energy communities through 5G and IoT technologies for flexibility services

- Energy box controler developed by CIRCE will be installed in houses
- Developement of centre for management of the island energy demand
- Two-level intelligance architecture
- Low capacity batteries will be analysed
- Developement of forcasting tools considering consumption, supply and external factors
- The inclusion of Blockchain for citizens to participate in the energy market will facilitate the creation of a local energy community

Local device for multiprotocol acquisition and distributed processing

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Transportni procesi

COASTENERGY- Blue energy in ports and coastal urban areas

- Project will strive to enhance the framework and background conditions for more intensive exploitation of blue energy potential within the cooperation area
- Lead partner is IRENA + 7 project partners from Italy and Croatia
- Aim of the project is to establish cross-border and local coastal HUBs on blue energy to foster development and deployment of blue energy devices to harness the potential of blue energy
- Special focus is given to the technologies like **wave converters and seawater heat pumps**, since they could be incorporated into existing or new port infrastructure and coastal urban areas
- Each partner will select pilot area for which needs to perform energy potential analysis within appropriate technology

Interreg Italy - Croatia COASTENERGY
EUROPEAN UNION

Figure 1- Programme area Interreg Italy-Croatia

Pilot location – Cres-Lošinj archipelag

- Project partner - SDEWES Centre
- Chosen technology - seawater heat pumps
- Aim is to carry out techno-economic assessment for the deployment of seawater heat pumps in the public buildings
- Specific objective is to analyse the potential for storing electricity surplus from variable renewables

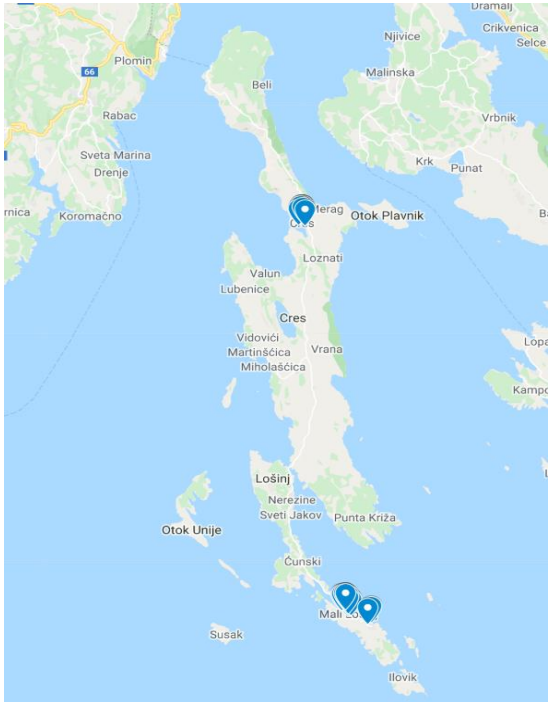

Figure 2- Locations of public buidlings on islands Cres and Mali Lošinj

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Iceland Liechtenstein Norway grants
Norway grants

Norway

Estonian islands

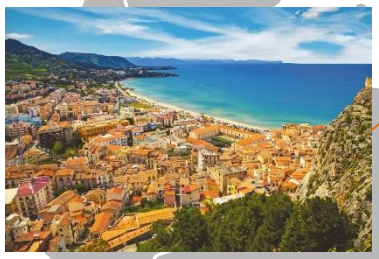
YENESIS - Youth Employment Network for Energy Sustainability in Islands

Greek islands

Croatian islands

Madeira

Canary Islands



Italian islands

Cyprus

Duration: 40 months

Direct Beneficiaries (NEETs): 84

Youth15-19 access to guides: 7000

Entrepreneurs (start-ups): 14

CO2 reductions: 2500 tons

General public reached: 26,000

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10/2018

Research
Sustainability competences for green jobs & Best practices

NEET
In educational programme

NEET
In showcasing trips in Norway

NEET
In apprenticeship in an EU island

Learning
Train target group in 4 thematic areas & business innovation
3-days showcasing trips
1-month apprenticeship

Application
6-month local placement
Business mentoring

NEET
Receiving business mentoring

NEET
In local placement

NEET
In networking opportunities

02/2022

Capitalisation
Stakeholder engagement
Policy recommendations

Long lasting impacts for NEETs
Sustainable Employment Opportunities
Green jobs
Start-ups

1. **A young professional's path for sustainable employment**
2. **Sustainable occupations for sustainable employment**
3. **Sustainability and transferability of YENESIS outputs (islands as test beds)**
4. **Prevent young people to become NEET**

- Currently there are no 100% renewable energy system on the islands, so there is a huge potential for demonstration
- Planning of energy system is important as costs can be reduced significantly by system integration
- Electricity as main energy carrier, do not forget water, wastewater, waste, heating and cooling or hydrogen and electrofuels in transport sectors
- Attracting of young people to plan their career, work and live on the islands

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THANK YOU FOR YOUR ATTENTION!

goran.krajacic@fsb.hr

Other projects

http://het.hr/

Phoenix Project (H2020-MSCA-RISE-2015)

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